PATENT SPECIFICATION

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499,024

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COMPLETE SPECIFICATION

Improvements in or relating to Centrifugal Separation

I, JUAN LOUMIET ET LAVIGNE, of Playa de la Teja, Itabo, Province of Metanzas, Cuba, a Citizen of France, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to the centrifugal separation of fluids.

The invention provides a method of separating a complex fluid stream into component parts comprising particles classified according to their densities, which comprises transmitting the fluid stream at high velocity while confining it to a helical path, to subject the fluid stream to a force which is the resultant of centrifugal force and of a gravitational force for first effecting a preliminary classification, then dividing the stream into two or more subsidiary streams and thereafter realigning the division into subsidiary streams from time to time to improve the classification, all while continuing the flow of the fluid in the helical path.

The invention also provides an apparatus for carrying the foregoing method into practical effect, comprising a curvilinear coil having a longitudinal bore; said bore being characterised by having, in cross-section, a contour of greater breadth than thickness, its major cross-sectional axis being disposed approximately in the direction of the resultant of the centrifugal and gravity forces acting upon said flowing stream, and said bore being divided lengthwise into segments all curving in the same direction, at least one of said segments being partitioned to arcuate segment zones adapted to receive and segregate the fluid components classified by the action of said forces within a preceding segment of said coil, and to deliver said components, further subdivided, for contact within the coil of adjacent portions of the output of each two adjacent segment zones.

The present invention finds useful application for example, in the separation of water from alcohol and in other similar operations, but it also has a special utility in the separation of gases which must be seperated at a very low temperature such as the gaseous constituents of the atmosphere. The principle of the invention will be outlined for example, in connection with the last mentioned application.

In accordance with a practical and advantageous method typical of the invention mixed gases or vapours are expanded into a helical coil, being caused to traverse successive sections of a path defined by the coil at a high velocity. The temperature of the expanded vapour is regulated and controlled with the object of promoting the condensation of the heavier, more readily condensed constituent, while hindering or preventing condensation of the lighter constituent. The centrifugal force induced by the travel of the fluid in a curvilinear path promptly throws all condensed liquid toward the outer side of the coil, and effects a partial or preliminary classification within the coil of the uncondensed particles in accordance with their densities. This preliminary classification is effected in the first or introductory section of the coil. The next coil section is subdivided by longitudinal partitions into concentric zones each carrying a roughly classified fraction of the vapour. The condensing, classifying and separating action is continued in each of these zones so that each of them may deliver some liquid from the region of its outer wall, and vapour from the remainder of its cross-section whose particles are better classified than when they entered the zone. The cross-section of the coil is desirably further subdivided in following sections, greater numbers of partitions being provided to produce a greater number of zone divisions.

At each point of redivision there is a regrouping of the vapours; that is to say, the denser vapours delivered by an inner zone and the lighter vapours delivered by an outer zone are delivered together to a single zone of the following section. This principle of rectification and reclassification is continued from point to point, even after the maximum subdivision of the coil

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into zones has been effected. Thus, particles which were originally classified improperly are permitted to seek their proper stream, the classification being progressively more perfect as the fluid progresses along the coil. The liquid condensed in an inner zone is also permitted to progress step by step outward until it is all collected in the outermost zone.

In order that the invention may be more readily understood, reference is made to the accompanying drawings, which illustrate diagrammatically and by way of example several embodiments thereof, and in which:—

Fig. 1 is a view in plan of a helical separator coil in the construction of which certain features of the present invention have been embodied;

Fig. 2 is a view thereof in side elevation;

Fig. 3 is a fragmentary detail view of a schematic character in sectional plan, of an individual convolution corresponding in general position to the lowest convolution of the coil shown in Fig. 2 but of a modified construction which will be described;

Fig. 4 is a view in schematic form illustrating in vertical section typical cross-sections of a tubular component of the structure shown in Fig. 1, at different stages of separation, these sections being taken respectively on the lines *4a*, *4b* and *4c*.

Fig. 5 is a schematic view in sectional plan of one complete convolution of the coil shown in Fig. 2 being that convolution the ends of which are defined by the reference characters 5—5 in Fig. 2;

Fig. 6 is a view similar to Fig. 5 illustrating a modification of the division into zones, and also showing extraction tubes;

Fig. 7 is a similar view, illustrating a further modification of the sub-division into zones;

Fig. 8 is a similar view illustrating still another modification of the zone arrangement and of the extraction tubes;

Fig. 9 is a schematic plan view, similar to Fig. 1, of a modified form of helical structure in the construction of which the invention has been embodied;

Fig. 10 is a schematic view in horizontal section illustrating devices projecting into a zone from an adjacent zone, for rectifying the classification of the liquids of different densities;

Fig. 11 is a fragmentary detail view in horizontal section on a much larger scale of that part of one helical convolution of the structure which is shown in Fig. 10, and also showing the scoop or rectifying device and its associated parts in detail;

Fig. 12 is a transverse sectional view on the line 12—12 of Fig. 11;

Figs. 13, 14, 15 and 16 are views of a character similar to Fig. 12, showing various typical cross-sections of the convolutions composing the tubular component of a helical separator structure in the fabrication of which this invention has been embodied;

Figs. 17, 18 and 19 are segmental views in detail, each illustrating a fragment of one convolution of a coil in which zones are disposed in different arrangements;

Fig. 20 is a schematic sectional view of a complete convolution similar in general arrangement to that of Fig. 10 but modified as to details of the zone structure, and of the extractor tubes;

Fig. 21 is a similar view of another modification;

Fig. 22 is a similar view of still another modification;

Fig. 23 is a fragmentary, detail view in vertical section on the line 31—31 of Fig. 24;

Fig. 24 is a fragmentary, detail view in vertical section on the line 32—32 of Fig. 22.

In said drawings like parts are denoted by like reference characters.

Referring first to the coil or helical structure, which is designated generally by the reference character H throughout the drawings, regardless of its particular shape in any specific embodiment of the invention, this helical structure is shown in Figs. 1, 2 etc., as having a terminal portion T of generally circular section, to facilitate its connection to a conventional supply pipe, and from the round terminal T the tube is gradually broadened in a radial direction and made corespondingly thinner, while maintaining a constant mean area, until it can be regarded as divided into at least two zones extending lengthwise of the tube, viz., an outer zone, designated generally S^1 throughout the drawings, being that portion of the bore most remote from the axis A of the helical structure, and an inner zone, designated generally S^{11} throughout the drawings, being that portion of the bore nearest said axis.

For the purpose of compactness in illustration, the length of convolution of the component tube comprised in the part from T to S (the character S indicating the region at which the typical cross-sectional form of the bore, as shown in the middle portion of Fig. 4, becomes established,) has been shown as relatively short, but in actual practice that length will preferably be of sufficient extent to permit a good initial classification of the fluid stream, so that the mixture running

through the outer zone may contain the greater part of the fluid, or of the impurities, of greater density, and so that the greater part of the lighter or less dense elements will be found within the inner zone.

The above initial classification of components of the fluid stream having been so effected, the bore of the coil is made progressively broader and thinner, usually without change of mean cross-sectional area, in order to permit further classification of the components of the fluid stream, and to permit, when desirable, their individual segregation, as, for example, into several zones, such as indicated at 4*b* and 4*c* in Fig. 4.

Such subdivision should only be effected when the initial classification of the component fluids has been accomplished to an extent adequate to permit the separation of quite distinct mixtures in the new divisions, the initial treatment having been carried out with due regard to the condition of impurity of the fluid, its viscosity, and difference in density and in rate of travel of the fluid stream.

In due course, following the same principle, the cross-sectional shape of the bore may be still further broadened and thinned, while maintaining its mean area, to permit further classification and subdivision of the zones by means of suitable partitions, four zones are shown at S4 in Fig. 1; five at S5; and six at S6.

By following another mode of subdivision each zone may be bisected at each subdivision, thus duplicating the zones each time, and Fig. 9 illustrates graphically an example of such subdivision, no detailed description of this Figure being considered necessary.

By means of such progressive enlargement in breadth to an indefinite extent, the shape of the tube will finally be brought to the relative breadth and thinness which shall have proved desirable to carry into effect the particular treatment intended for a fluid stream of given characteristics, the bore of the tube being divided and subdivided lengthwise by partitions into zones having divisions which will conform in number, in length, and in cross-section, to the desired treatment to be effected, the separation and segregation of fluid components being progressive to effect the disposition of the denser fluid components progressively outward, in proportion to their relative density.

It is to be noted that the system of division and subdivision may be modified in the respect that, as illustrated in Fig. 9 the early classifications may be carried on to a substantial extent by means of the simultaneous broadening and thinning of the bore, always maintaining its mean cross-sectional area without dividing the bore into sectors by physical partitions. Once this result has been obtained and the classification of the fluid components has been effected to a satisfactory extent in a given section of the tube, the bore may be so divided into various zones as to provide for the successive separation, in such zones, of fluid components of a relative density which increases progressively from that of the fluid in the zone nearest the axis, to that in the zone most remote from said axis.

Such division and separation can be effected either at the same time, or preferably in various operations, as by dividing the original area of the bore first into two or three zones, as shown in Fig. 1 and then by subdividing those zones afterwards in the manner hereinafter described. Fig. 9 shows the division of the original bore into eight zones by means of three successive partitionings, in each of which a zone is bisected, as at 51, 52 and 53.

Having obtained, in the manner above described, the division of the bore of the helical tube into zones, and thereby provided for the initial classification of the fluid stream in those zones, and also for further division to the desired degree of subdivision, there remains to be carried into effect another important object of the invention, comprising the step of rectifying the classification of the classified fluid components of the stream (hereinafter referred to as "rectification" or "rectifying operation").

By this step, provision is made for inducing the return to their appropriate zones of fluid components which have been diverted therefrom by unintended displacement in the course of the preceding step or steps of classification and separation; the general purpose of each rectification being to concentrate the denser bodies in the outermost zone, and the least dense components in the intermost zone.

Such rectification, in pursuance of this object of the invention, is accomplished by inducing contact between the denser fluid flowing in a relatively remote zone with the relatively less dense fluid flowing in the next inner zone of the system.

The preferred means to effect such contact of the fluid components to be rectified comprises the disposition of each partition by which a new pair of zones is formed in the system, in such fashion that the end of each such partition extends between the adjacent walls of the next anterior zone, i.e., the one from which issues the stream

to be divided, as for example, by the arrangement of the partition ends as at the regions 62, 63 and 64 in Fig. 5, so that each of the new zones, at each such region is fed by a predetermined portion of the fluid components flowing out of the anterior zone, the denser fluid component passing into the new outer zone and the lighter fluid component passing into the inner new zone.

In each of the above new zones, the new fluid streams produced from those mixtures become again classified, their denser components seeking the outer portion of the new zone, and their lighter components entering the inner portion of the new zone; and each new zone will be made of a length suitable to permit the completion of this step of the rectification operation; another subdivision of a similar nature being similarly effected, as at 59 and 60, by partitions disposed in the leading end of each of the zones 57 and 58 (Fig. 1).

Preferred means for carrying the foregoing object into practical effect are illustrated in Figs. 5 to 12 and 17 to 19.

Referring now to Fig. 5, which represents a section of the convolution 60 in Fig. 2, the fluid enters at the region represented by the section line 61, and at each quarter of the spiral, as at 62, 63 and 64, there is a further modification of the interior zones. It may be noted, however, that this quartering is merely illustrative, and that in practically all cases the fluid stream should be caused to travel through a longer stretch of each new modification of the internal structure in order to insure the performance of a re-classification adequate to justify another change of divisions.

It is also noteworthy that in Fig. 5 the new divisions of each pair are established approximately in the middle end of each anterior zone, although that disposition of each partition may be modified for the purpose of admitting from the anterior inner zone into the new zone such a proportion of the denser fluid components as may be regarded as more suitable; and for admitting from the anterior exterior zone a suitable portion of the lighter fluid which also feeds it.

The divisions which the new zones establish may be arranged to penetrate into the anterior zones, as shown in Fig. 5 and also as shown at 165 in Figs. 18 and 19, or can begin where the anterior zones end, as shown at 65 in Fig. 6; or they may be spaced somewhat from those ends, as shown in Fig. 17 and Fig. 18 at $65x$; or the disposition may be partly according to one such arrangement, and partly according to another, as also illustrated in Figs. 18 and 19.

In each case the divisions of the various zones may begin at the same point of each convolution, or at different points, as shown respectively in Figs. 5 and 9.

Rectifying operations may be effected without modifying the division into zones already described, by collecting the heavier part of the dense fluid of a zone S^{11}, as at 66 in Fig. 11, and injecting it into the adjacent outer zone S^1; also by collecting, as at 67, the lighter component flowing in said outer zone S^1 and injecting it into the aforesaid neighbouring inner zone S^{11}. Figs. 10, 11 and 12 illustrate means by which such a restification can desirably be accomplished for example, in the instance of a gas or vapor which it is desired to separate from a liquid which it carries, as in the case of a centrifugal distillation.

In general structure, the apparatus used for the last-named purpose may be as illustrated in Fig. 10 and its structural details are shown in Figs. 11 and 12, in which a scoop or stripper device 67 projects into the path of the lighter fluid component flowing through the zone S^1, and deflects or diverts it into the zone S^{11} while the small tube 66, inserted in the small channel 68 which the zone S^{11} forms at its outer end, collects and carries into the zone S^1 the liquid separated in the zone S^{11} and which accumulates in said small channel 68.

Having established within the successive zones of the helical structure, by means of the primary classification and the subsequent rectification, a graduation of the fluid components progressively denser from the inner zones outwardly, the method of the present invention may be carried into effect for the further purpose of accomplishing the separation of such fluids as that by which the separator system is fed; and for that purpose these fluids which are to be separated are injected into one of the intermediate zones; and in proportion to the quantities so injected respectively heavy fluids will be extracted from an outer zone of such a system and light fluids from a zone nearer the axis of the helical structure.

In Figs. 22 to 24, a means for effecting the last-named extractions is illustrated, which means includes an enlargement, as at 70, of the central zone 71 where it is to receive the injection of the fluids to be separated, the latter being supplied through an injector pipe or nozzle I. The divisions of the successive zones are so modified that they preserve a mean cross-sectional area, except at their ends, which are somewhat reduced in size, the

reductions corresponding to the extractions of fluid components which may be effected.

Afterwards, the aforedescribed rectification of the classified fluids is effected, by means of which the division of the bore into zones as initially disposed is re-established, and the classification of the fluid components is completed. When that classification has proceeded sufficiently far, a new injection and new extraction are effected.

Fig. 22 illustrates in schematic section, a convolution of the helical structure, shown as flat, for the purpose of illustration, and Fig. 23 is a fragmentary detail view in vertical section on the line 31—31 of Fig. 24; Fig. 24 being a similar vertical sectional detail on the line 32—32 of Fig. 22.

In these Figures, the injection tube, as already noted, is designated I; that for the extraction of dense fluid E^1 and that for the extraction of light fluid E^{11}, the character E designating the main discharge pipe of the system.

The foregoing operation may be regarded as accomplished in one complete convolution of the helical structure, between successive injections, but it is to be understood that these dispositions are susceptible of extensive variations, according to the requirements of particular extractions, and that the frequency of the injections must depend upon the condition of the fluid, upon the nature of the separation, upon the completeness of extraction required, and upon the velocity of the fluid.

In Fig. 21 a modified form of means is illustrated for effecting the injection and other operations without modifying the interior section of the tube, this modification of method consisting primarily in deflecting toward an adjacent outer zone any denser fluid components flowing in a given zone 72, as at 73, and deflecting toward an adjacent inner zone, as at 74, the lighter fluid component flowing in the zone 72.

The length of that part of the coil designed for separation of the newly injected fluid will be determined in each instance by the character and requirements of the extraction to be effected, and in general such modifications may be adopted as will occur to those skilled in the art, without departing from the idea of means which underlies the invention.

In further pursuance of the invention, a means is provided for the eventual disposition of a classified or partly classified fluid which acts as a carrier fluid which runs through that part of the helical structure posterior to that devoted to the injection and extraction operations above described, and which carrier fluid constitutes the instrument of separation utilized in the aforesaid steps of injection and extraction.

In the last-named step of provision for eventual disposal, it may be found convenient in some cases to continue using said carrier fluid and to feed the coil by recirculation thereof, and for that purpose the used fluid may be at first bumped from the part of the coil designed for separation of newly injected fluid, i.e., after the primary rectification, and before initiating the extractions. Separate pumping facilities will be provided for each zone, and the provisional feeding to the injector will be suppressed as soon as self-feeding has been established, closing the cycle of the operation; also suppressing, in consequence, the operations in that part of the coil anterior to the place where the pumping is effected.

It is to be noted that the circulation of the united fluids described from a group of zones which originated in a primitive zone can also be effected by pumping the united fluids from such zones into that primitive zone, or finally the totality of the mixed fluids can be pumped at the intake of the coil, as at T (see Figs. 1 and 2). Generally, however, it will be more practical to dispose of those circulating fluids by carrying the separation of their fluid components through to a degree of completeness which results in their discharge individually for further use.

Inasmuch as, in this case, there is a cessation of feeding movement of the fluids, for injection into the coil of the fluids to be separated, the volume of the total fluid in circulation, or available for circulation, is diminished by the extractions of separated light and dense fluid components which shall have been effected; and, in order to maintain the velocity of travel of that fluid, it is necessary to reduce also the cross-sectional area of the bore of the coil tube. That reduction can be obtained by diminishing its thickness, and maintaining its breadth, or by diminishing its breadth and maintaining its thickness; or by diminishing both of its cross-sectional dimensions.

In Fig. 6 is shown schematically an instance in which the breadth of the tube is maintained while the thickness is diminised. All the extractions of the light fluid through E^{11} and E3 are united in a single discharge pipe E, while the exterior extractions are effected through a peripheral pipe E^1 and another pipe Ex. These extractions can be effected in such a manner as to absorb the totality of the fluids from the zone, as at E3 and E^1, or

only such selected parts thereof as may be drawn off at E^{11} and Ex.

Fig. 7 illustrates an example of diminishing the breadth of the bore S6 while at the same time retaining or not retaining its thickness undiminished. In this instance the breadth of each of the zones is also reduced, as at Sx, so as to maintain the same number of zones.

After each extraction, referring both to the instance illustrated in Fig. 6 and to that in Fig. 7, the residual fluid in the zone is subjected again to a rectification before effecting a new extraction, the coil presenting again those changes of section as hereinbefore described, and the interval between two successive extractions is determined by the need for a certain amount of travel, so that the fluid may become sufficiently rectified to accomplish the purpose sought by the separation.

It will be understood, of course, that inasmuch as Figs. 6 and 7 are only schematic in character they are intended to suggest symbolically the nature of the step performed and do not show actual structure in detail. In each instance of separation the requirements will be found to be different and the actual structure will be varied by those skilled in the art to meet the particular requirements encountered in the practice of the novel method herein disclosed.

When, by virtue of the successive extractions, the thickness of the pipe has been reduced to the minimum practically possible, and its breadth to the minimum allowed for the maintenance of the same number of zones, it is unavoidable, in order to dispose of the residual fluid, to diminish gradually the number of sectors in the same measure that the extractions are being effected.

Figs. 3 and 8 illustrate how that disposal can be effected, provision having been made in the structure thereof for effecting a new rectification of the fluid after each extraction, these figures having the same schematic character already noted. In Fig. 3, the number of zones shown at S7 is reduced in number to a single zone at S8.

In Fig. 8 the larger number of zones at the central portion of the system is reduced to three zones S9 at the periphery and three zones S10 at the central portion, the extractions having been effected at S12.

It will be understood that the rectification may be performed in a considerably larger space than that represented in the last-named figures, since, after each extraction, there should be allowed an ample period for completion of the analysis of the total.

While the process has been described, thus far, in its application to the separation of two fluids of different densities, such for example as used lubricating oils which are to be purified, and such as the mechanical purification of raw petroleum, etc., it can be utilized for other purposes, as for example in the defecation of sugar cane juice, in which instance the impurities which must be separated include substances denser than the juice, constituting a heavy scum, and lighter substances which constitute a light scum.

As applied in this instance, the outermost and innermost extractions will be respectively of heavy scums and of light scums, but the extraction at these extremes will be limited to the separation of those impurities, and when the residual cane juice has been sufficiently purified it can be extracted from the central zone continuously as it reaches the desired condition of purity, and in a manner corresponding to the extractions of the denser and lighter fluids in the instances already described by way of example.

Such extractions will be effected in the central zones at a region shortly anterior to that in which the impure juice is injected, the thickness of the central zones being reduced at the region of such extraction and the typical dimension re-established at the region of injection of the impure fluids.

In place of a zone or group of zones, comprised in the helical structure of a single operating coil, as described, use may be made of several successive, or individualized coils, each one of which would replace a zone or group of zones of the described apparatus and would operate in the manner described, without necessitating any essential change in the principle of operation.

Having now particularly described and ascertained the nature of my said invention, and in what manner the same is to be performed. I declare that what I claim is:—

1). A method of separating a complex fluid stream into component parts comprising particles classified according to their densities, which comprises transmitting the fluid stream at high velocity while confining it to a helical path, to subject the fluid stream to a force which is the resultant of centrifugal force and gravitational force for first effecting a preliminary classification, then dividing the stream into two or more subsidiary streams, and thereafter re-aligning the division into subsidiary streams from time to time to improve the classification all the while continuing the flow of the fluid in the helical path.

2). Method as claimed in claim 1, in which the re-aligning step comprises dividing each of two adjacent subsidiary streams into inner and outer portions, and merging the outer portion of the inner stream with the inner portion of the outer stream to form a new, composite subsidiary stream.

3). Method as claimed in claim 1, in which a stream having relatively dense particles and a stream having relatively light particles are flowed continuously in juxtaposition with an intermediate stream or streams, said method comprising the step of injecting into said intermediate stream an addition of fresh fluid to be classified, and the step of extracting concurrently one or more of the classified fluid components.

4). Method as claimed in claim 3, in which the innermost and outermost streams are discharged separately, and the products of the intermediate stream are subjected to classification after which a new injection and a new extraction are effected.

5). Method as claimed in claim 1, in which the classification is carried out in a helical tubular structure the bore of which is divided longitudinally into several segments, said method comprising the step of rectification or extraction from each segment, except the outer-most, of the denser fluid which runs in that segment and by the injection of said extract into the segment nearest outwardly to the segment from which extraction has been made; also the step, performed concurrently, of extracting from each segment, except the innermost segment, of the lighter fluid, and its injection into the segment nearest inwardly to the segment from which said extraction of the lighter fluid has been made; thereby permitting transfer by action of the classifying force, of particles improperly entrained in an alien stream, each to its appropriate stream.

6). The method of separating a complex fluid stream into component parts, substantially as described.

7). An apparatus for separating a fluid complex into a plurality of components parts according to the method of claim 1, comprising a curvilinear coil having a longitudinal bore; said bore being characterised by having, in cross-section, a contour of greater breadth than thickness, its major cross-sectional axis being disposed approximately in the direction of the resultant of the centrifugal and gravity forces acting upon said flowing stream, and said bore being divided lengthwise into segments all curving in the same direction, at least one of said segments being partitioned to arcuate segment zones adapted to receive and segregate the fluid components classified by the action of said forces within a preceding segment of said coil, and to deliver said components, further subdivided, for contact with the coil of adjacent portions of the output of each two adjacent segment zones.

8). Apparatus as claimed in claim 7, in which the coil comprises a generally helical structure including numerous convolutions coiled progressively with respect to the main axis of the helical structure, the primary classification and separation of the fluid components being effected in an intake convolution or convolutions having a bore portion of substantially circular cross-section merging into a bore portion of said typical section as claimed in claim 7.

9). Apparatus as claimed in claim 6, in which a plurality of successive zoned segments are provided, the successive segments being differently zoned with radial over-lapping of zones of the two segments to cause re-division of the products of the first segment in the second segment.

10). Apparatus as claimed in claim 7, in which a plurality of successive zone segments are provided, and in which the first partitioned segment is formed with two zones and each succeeding segment is formed with a greater number zones until a desired maximum is attained.

11). Apparatus as claimed in claim 7, in which a plurality of successive zone segments are provided, the successive segments being differently zoned and in which the zoned partitions of successive segments are overlapped circumferentially of the coil.

12). Apparatus as claimed in claim 7, in which a plurality of successive segments are provided, the successive segments being differently zoned and in which adjacent ends of zone partitions of successive zone segments are in some instances spaced circumferentially of the coil.

13). Apparatus as claimed in claim 7, in which a plurality of successive zone segments are provided, the successive segments being differently zoned and in which certain segments include two or more zones and in which each intermediate zone of each segment other than the last discharges into two zones of the next following segment.

14). The apparatus for separating a complex fluid stream into component parts, constructed, arranged and adapted to operate, substantially as described with reference to the accompanying drawings.

Dated this 14th day of May, 1937.

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Chancery Lane, London, W.C.2.
Agents for the Applicant.

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Fig.1.

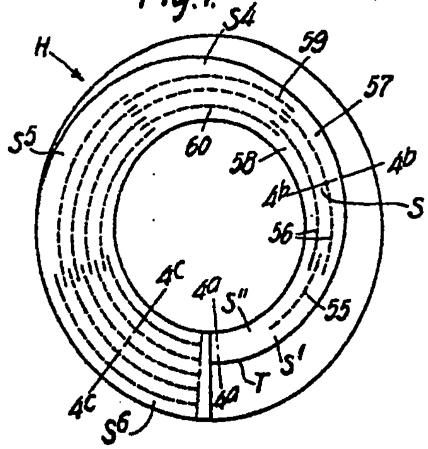


Fig.4.

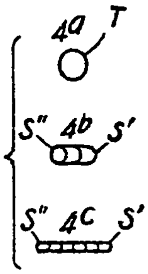


Fig.2.

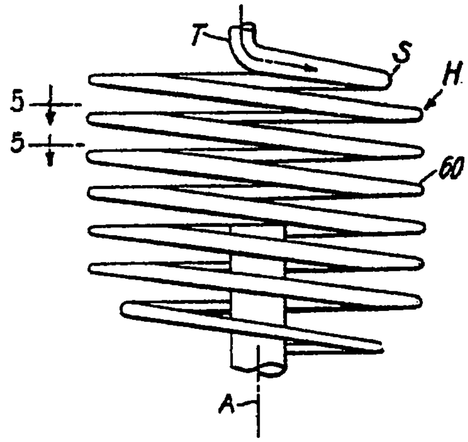


Fig.5.

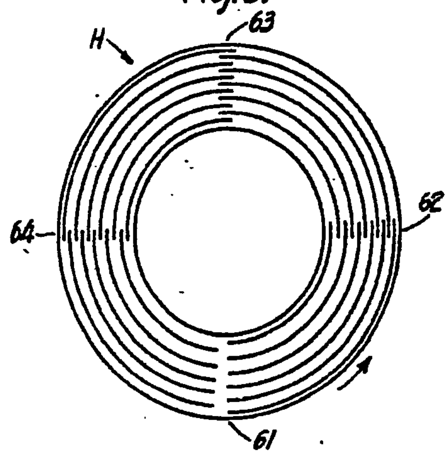


Fig.3.

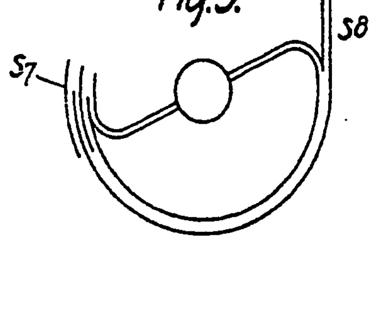


Fig.6.

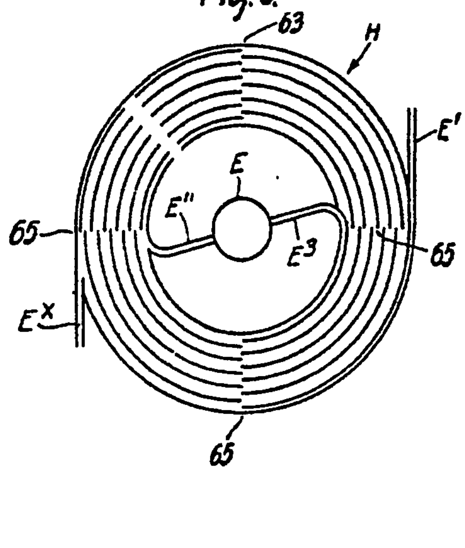


Fig.7.

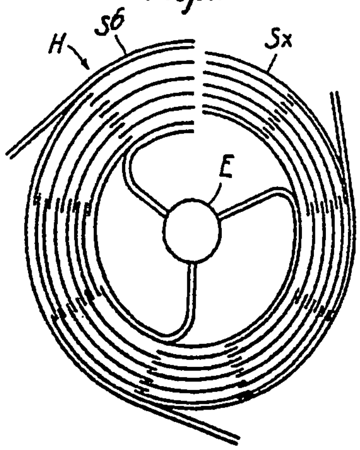


Fig.8.

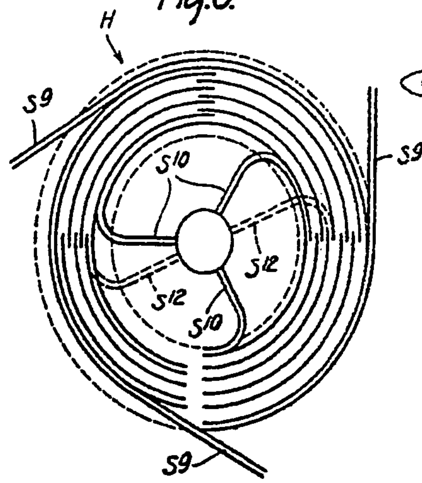


Fig.13.

Fig.14.

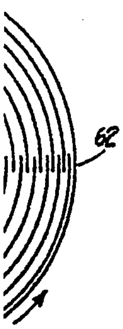


Fig.9.

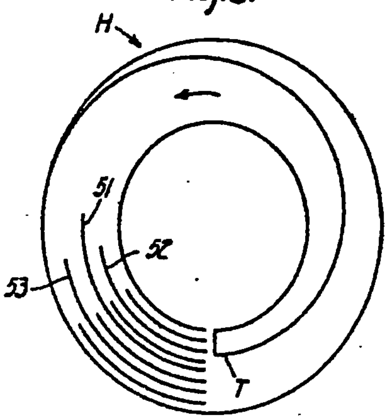


Fig.10.

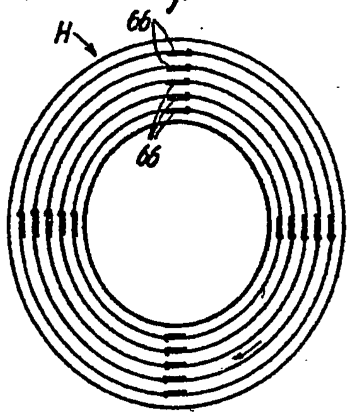
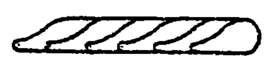


Fig.15.

Fig.16.



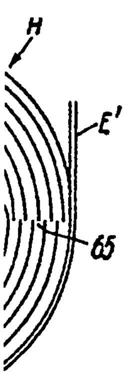


Fig.12.

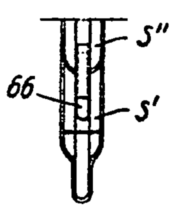
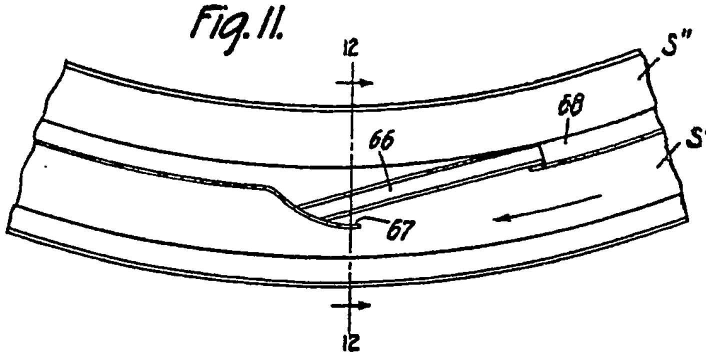


Fig.11.



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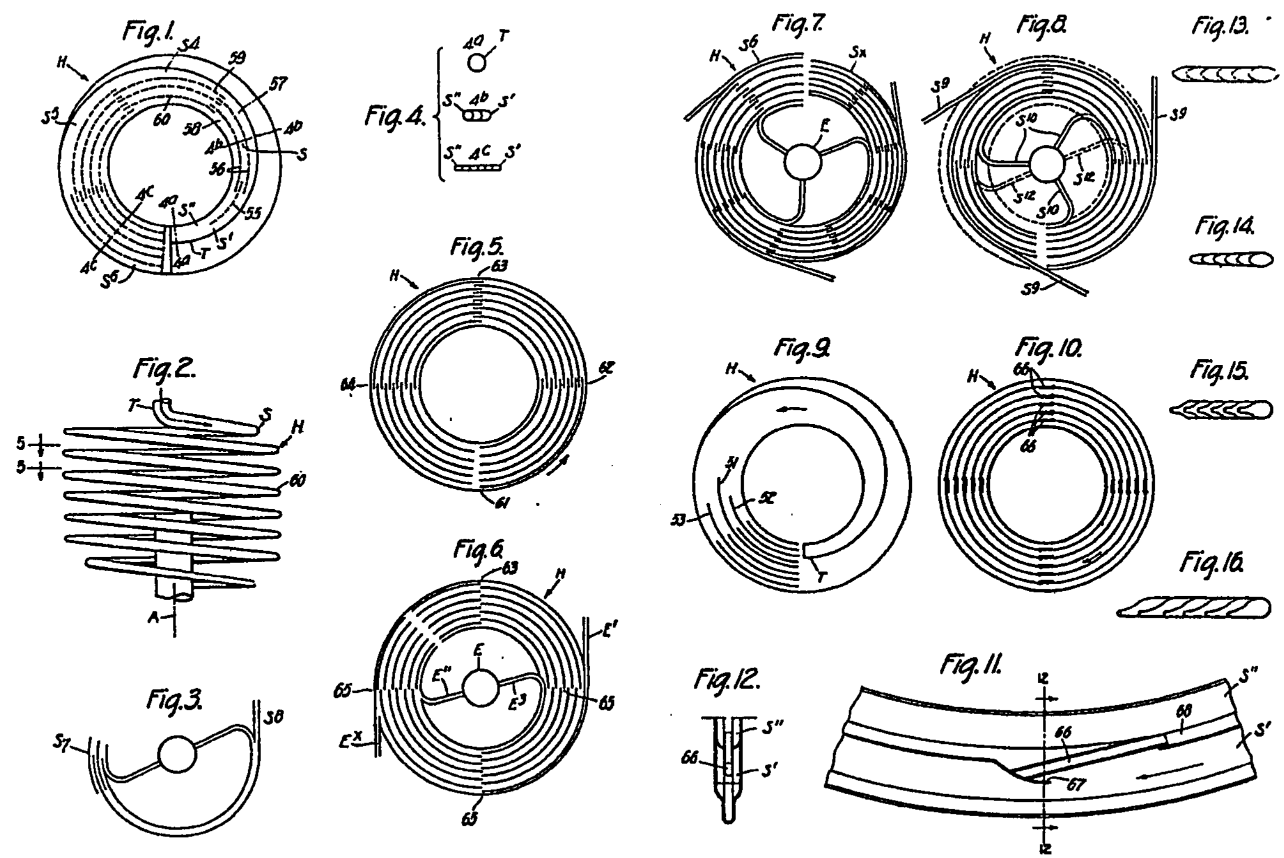

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Fig 17.

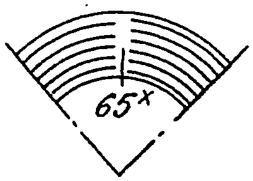
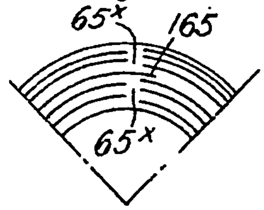


Fig. 18.



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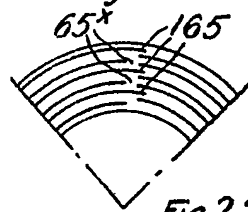


Fig. 22

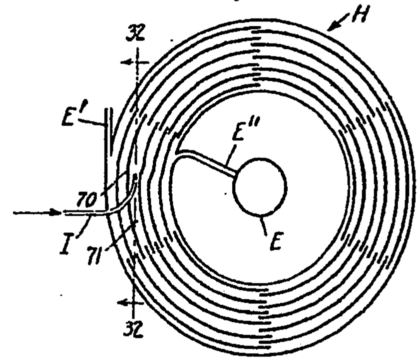
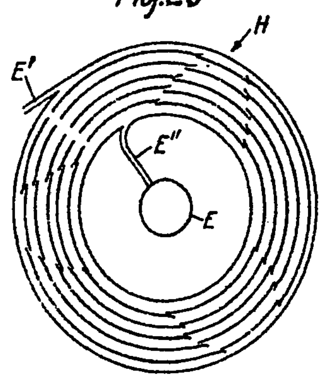


Fig. 20



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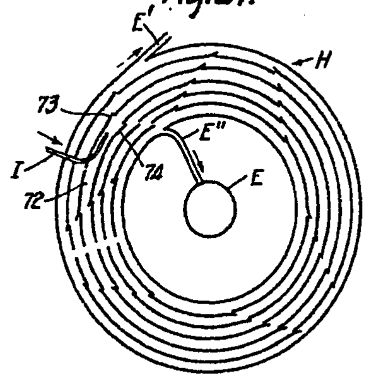


Fig. 23.

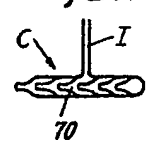
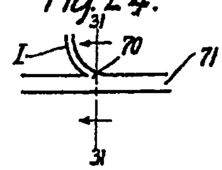


Fig. 24.



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